Lettuce

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Scientific Name and Introduction: The four distinct types of lettuce produced in the U.S. are crisphead or iceberg (*Lactuca sativa* L., var *capitata*), butterhead, bib or Boston (*L. sativa*, var *capitata*), cos or romaine (*L. sativa*, var *longifolia*), and leaf, (*L. sativa*, var *crispa*). Two others types, stem or celtuce (*L. sativa*, var *asparagina*) and Latin are rarely found outside local or ethnic communities. Crisphead lettuce produces large, heavy, compact folded heads with crisp, brittle, prominently veined leaves. Butterhead lettuce forms open heads with softer leaves having a smooth texture. Cos lettuce does not form a true head, but is composed of upright, large, elongated and often coarser leaves. Leaf lettuce also does not produce a head, and the leaves are more spreading, delicate, smaller and less elongate than cos.

Crisphead lettuce is the predominant type grown in the U.S. and is best adapted for long distance shipment. A greater percentage of all types of lettuce are being processed into fresh-cut salad mixes for commercial and home use. With proper vacuum cooling and packaging, refrigerated transportation under controlled atmospheres can supply whole and packaged lettuces to national and international markets.

Quality Characteristics and Criteria: Head lettuce should be solid, with no seed-stem, defects or decay. In general, high quality lettuce should be clean, free of browning, crisp and turgid, and bright light green.

Horticultural Maturity Indices: Head lettuce is harvested when the heads are well formed and solid (Ryall and Lipton, 1979). Maturity is based on head compactness, and the firmness of the head is related to its susceptibility to certain postharvest disorders. Soft heads are easily damaged while fairly firm heads have a higher respiration rates. Firm heads have maximal storage-life, while hard and extra-hard heads are more prone to develop russet spotting, pink rib and other physiological disorders.

Grades, Sizes and Packaging: Head lettuce is graded by size and firmness, while leafy types are graded by size (Hardenburg et al., 1986). Lettuces, as with other leafy vegetables, must be kept clean and free of soil and mud. This is easier when grown on mineral than on muck (organic) soils. A strong bitter taste and toughness develops if harvest is delayed or if over-mature, and then the product becomes unmarketable.

Because lettuce is very fragile, it should be handled as little as possible. Field packing and palletizing eliminate a major source of mechanical damage, but they require specialized handling equipment and vacuum cooling facilities to be practical. The stem is cut at ground level and the head trimmed of unusable leaves. Harvesting and field packing by hand is assisted by a variety of equipment that includes conveyors and mobile packing stations. Heads can be wrapped or bagged in plastic film by the cutter or packer. Wrapped or loose heads are then placed in cardboard containers that are stapled closed and palletized. Leaf, butterhead and cos types are cut, trimmed and tied into compact bundles before placing in cartons.

Crisphead or iceberg lettuce is usually packaged in 20 to 22 kg (43 to 48 lb), 24-count, cartons. Cos or romaine lettuce is commonly packaged in 24-count cartons. Leaf lettuce is usually packaged in 9 to 11 kg (20 to 25 lb) or 24-count cartons. Butterhead or Boston lettuce is usually packaged in 9 kg (20 lb) cartons. Bibb and greenhouse grown lettuce is commonly packaged in 4.5 kg (10 lb) cartons.

Lettuce harvested for processing is placed in large bulk bins for transportation to the pre-cooling or processing facility. Lettuce may be cored in the field or at local or regional processing facility. At the processing facility, heads are cut, washed in cold water, and centrifuged to remove excess water. Cut

lettuce is often mixed with other types of lettuce or greens, shredded carrot and/or red cabbage to produce a bag salad mix. The mix may be treated with a processing aid composed of a chlorine-containing compound and/or an antioxidant or preservative during washing or before packaging. The package is made from special films that are selected to maintain a desired lower O_2 and higher CO_2 concentration than in air. The bags are then placed in cartons for temporary cold storage or for immediate shipment to market. Since gas composition in bags results from a dynamic interplay between tissue respiration and film permeability, it is important to maintain proper temperature and to know the respiratory characteristics of the enclosed tissue.

Pre-Cooling Conditions: Vacuum-cooling is the preferred method for pre-cooling all lettuces (Hardenburg et al., 1986; Ryall and Lipton, 1979). For effective vacuum-cooling, containers and film wraps are perforated or readily permeable to water vapor. To aid cooling, clean water is sprinkled on the heads of lettuce prior to carton closure if they are dry and warmer than 25 °C (77 °F). A modification called hydro-vacuum reduces water loss during cooling. Thorough pre-cooling is essential because mechanically refrigerated trucks do not have enough cooling capacity to cool warm lettuce during transit. Field heat retained in the densely packed cartons can be removed by forced-air where vacuum-cooling facilities are not available, but it is much less effective. Hydro-cooling is effective for non-heading lettuce types, but should not be used with head lettuce since the water retained in the head fosters decay.

Optimum Storage Conditions: Lettuce should be quickly cooled and maintained as close to 0 °C (32 °F) as possible with 98 to 100% RH. Head types are better adapted to prolong storage than are the other types, but none keep longer than 4 weeks, and about half that time at 5 °C (41 °F). Film liners or individual polyethylene head wraps are desirable for attaining high RH; however they should be perforated or be permeable to maintain a non-injurious atmosphere and to avoid 100% RH on removal from storage. Lettuce is easily damaged by freezing, so all parts of the storage room must be kept above the highest freezing point of lettuce of -0.2 °C (31.6 °F).

Although most lettuce is hand harvested, some mechanical harvesters are available for product destined for processing into bag mixes. The attendant greater damage to the tissue and the induced higher rates of respiration and water loss requires greater attention to maintaining the optimal storage conditions of temperature and RH.

Controlled Atmosphere (CA) Considerations: Lettuce, especially crisphead and fresh-cut respond favorably to CA (Saltveit, 1997a). Levels of 1 to 3% O_2 at temperatures of 0 to 5 °C (32 to 41 °F) reduce russet spotting in susceptible lots. Intact heads do not benefit from elevated CO_2, and injury, ie., brown stain, may develop when lettuce is transferred from storage in > 2% CO_2 to air at 10 °C (50 °F) (Ke and Saltveit, 1989). A 2 to 5% O_2 atmosphere maintains appearance of lettuce and inhibits pink rib and butt discoloration compared to air. Brown stain is intensified when O_2 is reduced to 2 to 3%, but the effect differs with cultivar. If lettuce needs to be in transit overseas for a month, an atmosphere of 2% CO_2 + 3% O_2 is recommended, because the reduction in decay achieved by 2% CO_2 outweighs the danger of injury. Romaine and leaf lettuce appear to tolerate a slightly higher CO_2 level when packaged than head lettuce. Browning is a major problem with fresh-cut lettuce, and is controlled by packaging in < 1% O_2 and 10% CO_2 atmospheres (Lopez-Galvez et al., 1996; Smyth et al., 1998). The elevated level of CO_2 is more effective at reducing browning of the cut surfaces than it is at inducing brown stain.

Retail Outlet Display Considerations: Maintain cold conditions to maximize storage and shelf-life, minimize dehydration with periodic sprays of cold water. Avoid storage with commodities that produce ethylene; eg., apples, tomatoes. All lettuces are very susceptible to water loss, ethylene-induced disorders, and rapidly deteriorate at elevated temperatures.

Chilling Sensitivity: Not chilling sensitive, but freezing at -0.2 °C (31.6 °F) must be avoided.

Ethylene Production and Sensitivity: Ethylene production is very low, but exposure to ethylene can result in damage such as russet spotting and leaf yellowing.

Respiration Rates:

Temperature	Head lettuce	Leaf lettuce
	(mg CO_2 kg^{-1} h^{-1})	
0 °C	6 to 17	19 to 27
5 °C	13 to 20	24 to 35
10 °C	21 to 40	32 to 46
15 °C	32 to 45	51 to 74
20 °C	51 to 60	82 to 120
25 °C	73 to 91	120 to 173

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

Physiological Disorders: Some of the more common disorders of head lettuce include tipburn, russet spotting, brown stain, and pink rib (Ryall and Lipton, 1979; Saltveit, 1997b). Hard heads are more susceptible to these disorders than firm lettuce. Tipburn is of field origin, but occasionally increases in severity after harvest. Leaves with tipburn have brown, often necrotic leaf margins. Russet spotting, which is caused by exposure to ethylene and its induction of the synthesis, accumulation and oxidation of phenolic compounds at temperatures around 5 °C (41 °F), occasionally causes serious losses. Russet spots appear as dark brown, oval lesions on the midribs, and on the green leaf tissue in sever cases. It is easily controlled by making sure the storage atmosphere is free of ethylene and that the temperature is below 2 °C (35.6 °F). Lettuce should not be stored with ethylene producing commodities like apples, cantaloupes, pears, and peaches. Storage in a low O_2 atmosphere (1 to 8%) is very effective in controlling russet spotting. Brown stain is cause by exposure to > 2.5% CO_2 and appears as large, irregular shaped brown spots or streaks mostly on the midrib. Pink rib occurs in over-mature heads stored at elevated temperatures and appears as a diffuse pink discoloration of the midrib. The cause of this disorder is unknown.

Postharvest Pathology: Bacterial soft-rots, the most serious disease of lettuce, often starts on bruised leaves, and result in a slimy breakdown of the tissue (Saltveit, 1997b). A similar breakdown of tissue follows fungal infection by *Sclerotinia* and gray mold rot caused by *Botrytis cinerea*. Trimming and storage at 0 °C (32 °F) greatly reduces the severity of these disorders.

Quarantine Issues: None.

Suitability as Fresh-cut Product: Very high, especially in salad mixes with other leafy greens.

Special Considerations: Lettuce is fragile and must be handled with care to avoid mechanical damage and to minimize discoloration and pathological problems. Temperatures must be kept low and RH high to prevent loss of turgor and wilting. Ethylene must be avoided.

References:

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